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(54) **RECORDING APPARATUS**

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B41J 2/01 (2006.01)

(52) **U.S. Cl.**
USPC **347/19**; 347/102

(58) **Field of Classification Search**
USPC 347/9, 14, 19, 23, 44, 47, 100, 102, 347/106, 238
See application file for complete search history.

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(57) **ABSTRACT**

A recording apparatus includes a transportation mechanism that transports a recording material, a recording head that discharges photoactive liquids, a light irradiation section that irradiates the discharged photoactive liquids with light, and a failure detection section that detects failure of light emitting devices in the light irradiation section. This recording apparatus executes recording by masking a nozzle opening which corresponds to a failed light emitting device, when the failure detection section detects the failure.

4 Claims, 7 Drawing Sheets

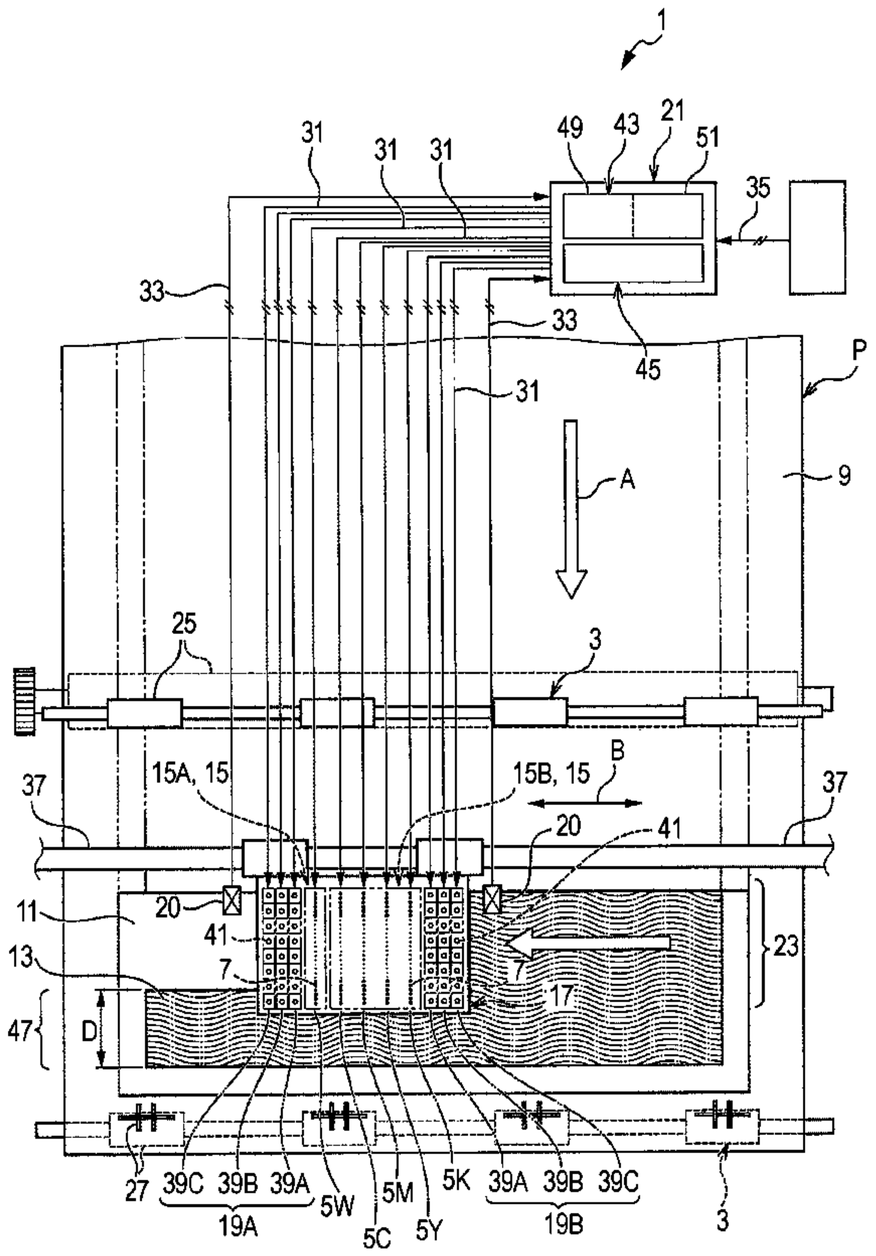


FIG. 1

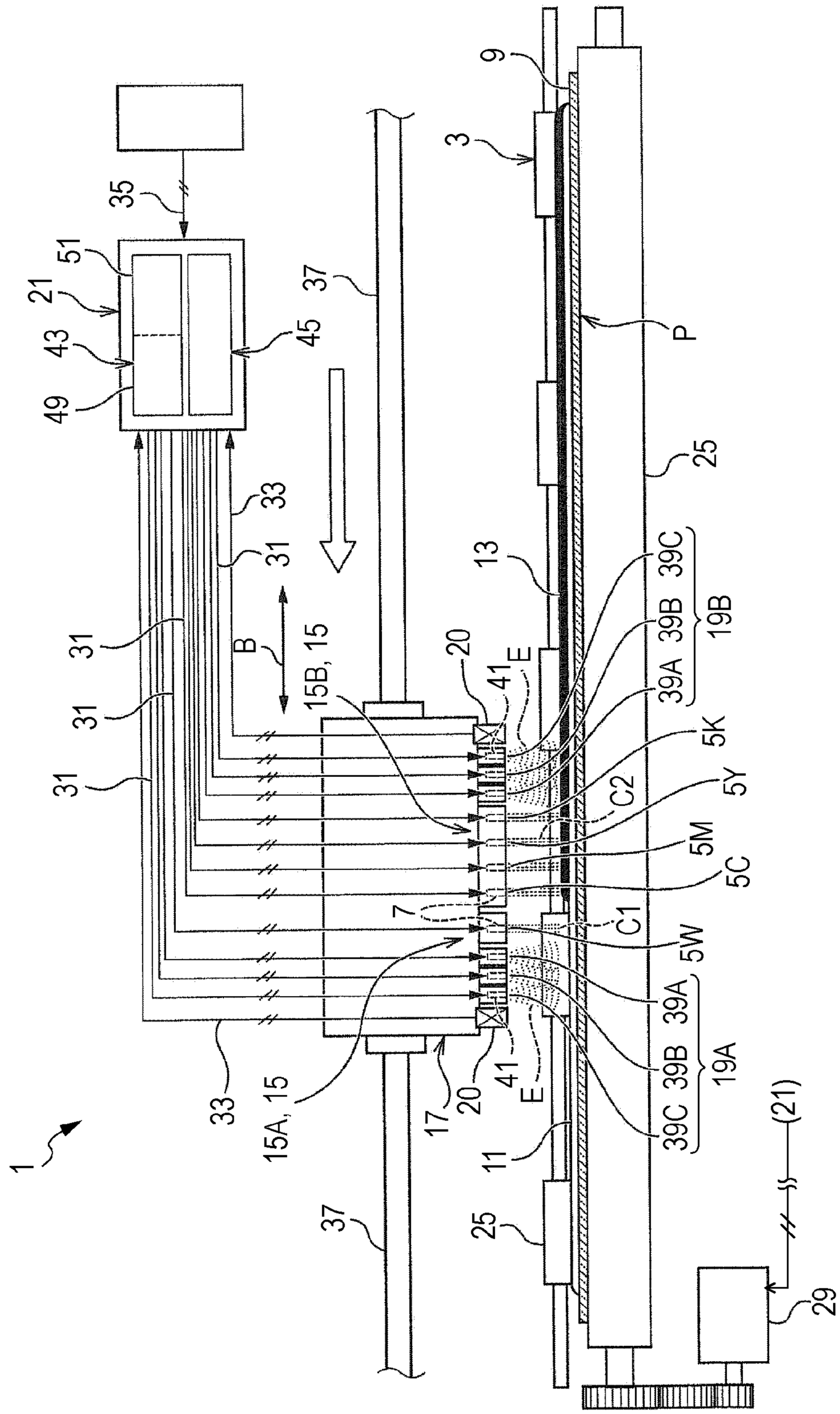

1
35
51
21
43
49
45
37
9
3
P
25
33
31
B
15B, 15
20
41
E
13
39C
39B
39A
19B
5K
5Y
C2
5M
5C
C1
5W
7
15A, 15
17
11
19A
(21)
29

FIG. 2

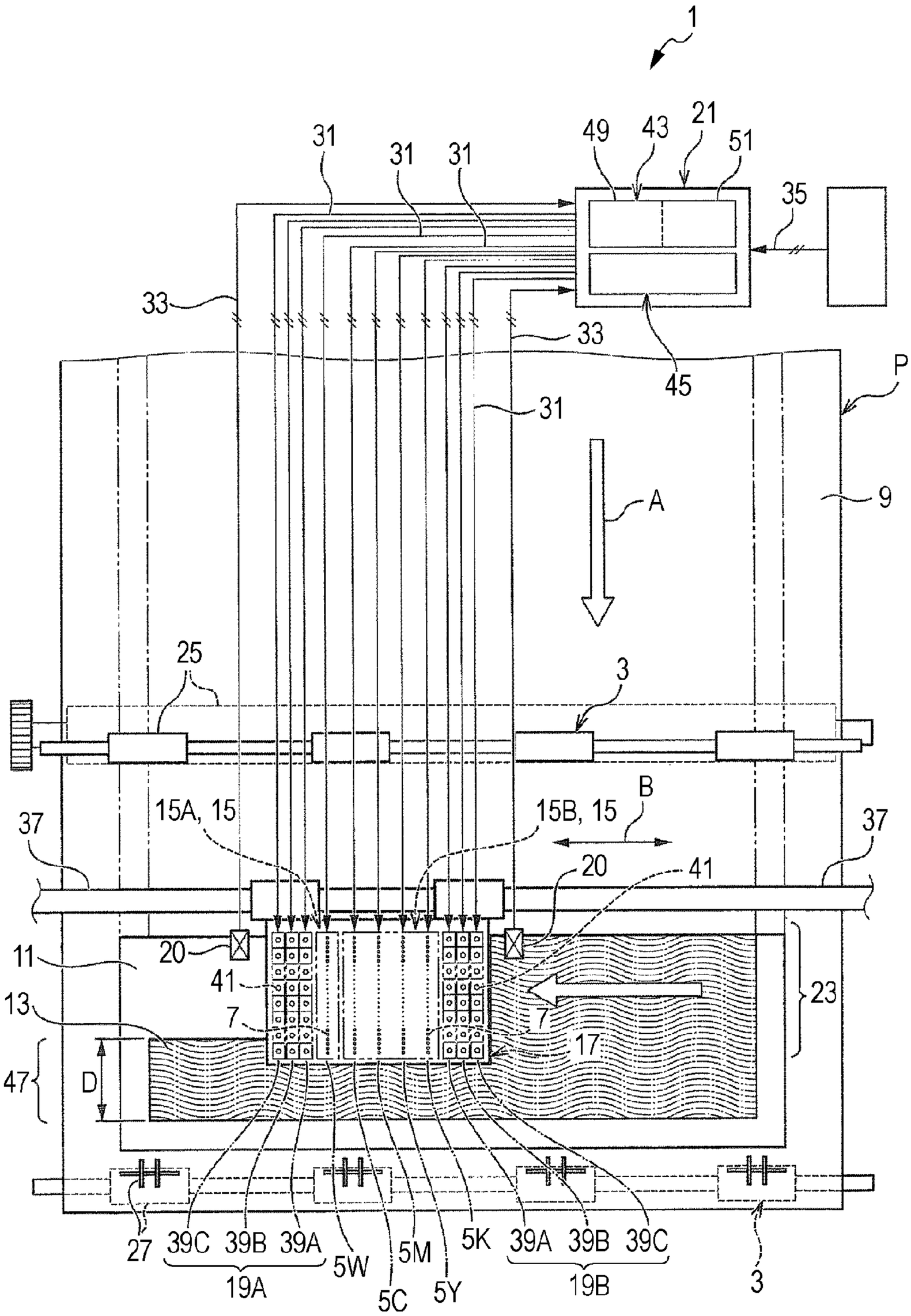

1
31
31
31
49
43
21
51
35
33
33
45
P
31
A
9
25
3
B
15A, 15
15B, 15
37
37
20
41
20
41
11
13
7
7
17
23
47
D
27
39C
39B
39A
5W
5C
5M
5Y
5K
39A
39B
39C
19A
19B
3

FIG. 3

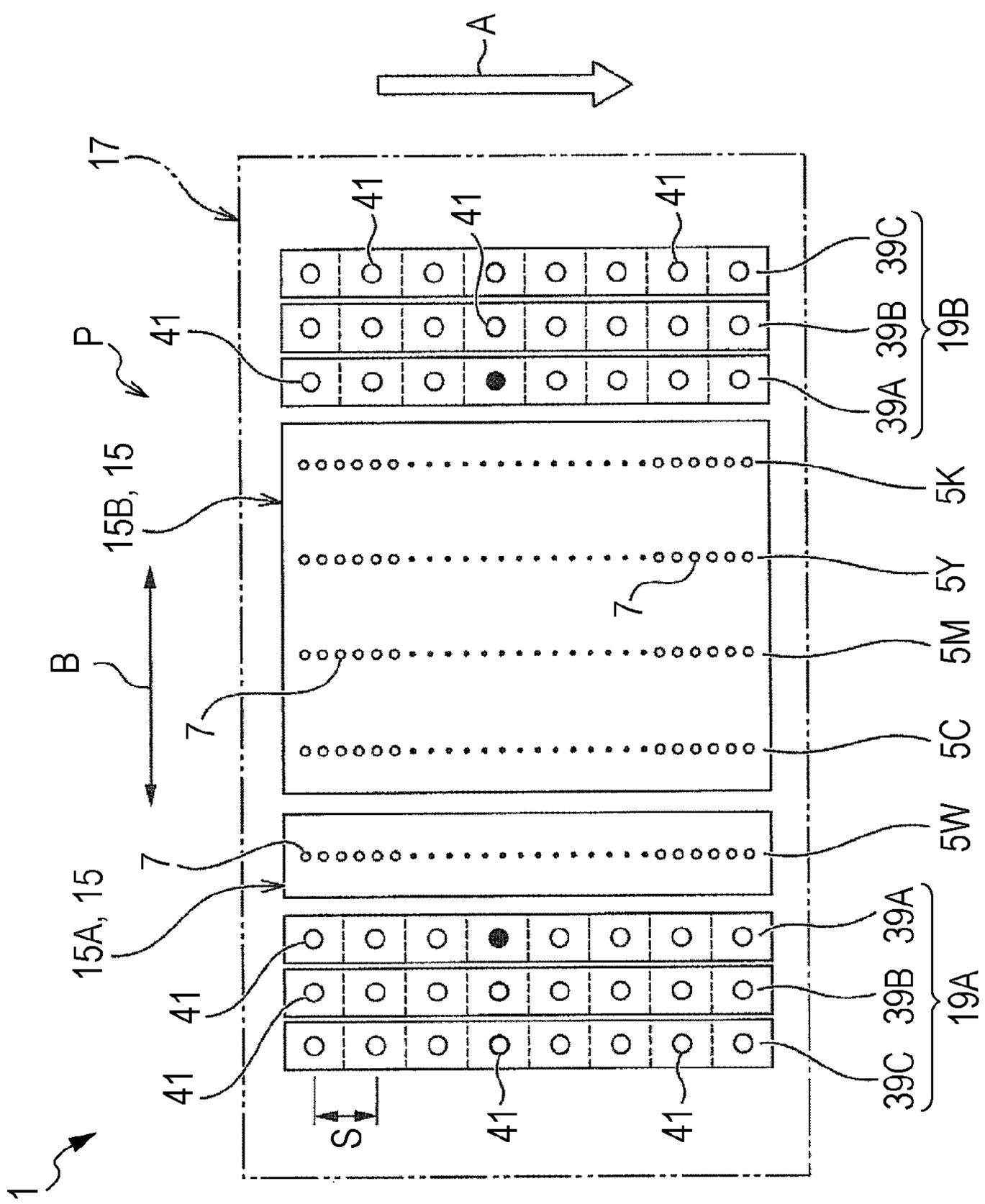

A
17
41
41
41
P
41
39C
39B
39A
19B
15B, 15
5K
5Y
5M
5C
5W
B
7
7
7
15A, 15
41
41
39A
39B
39C
19A
S
41
41
1

FIG. 4

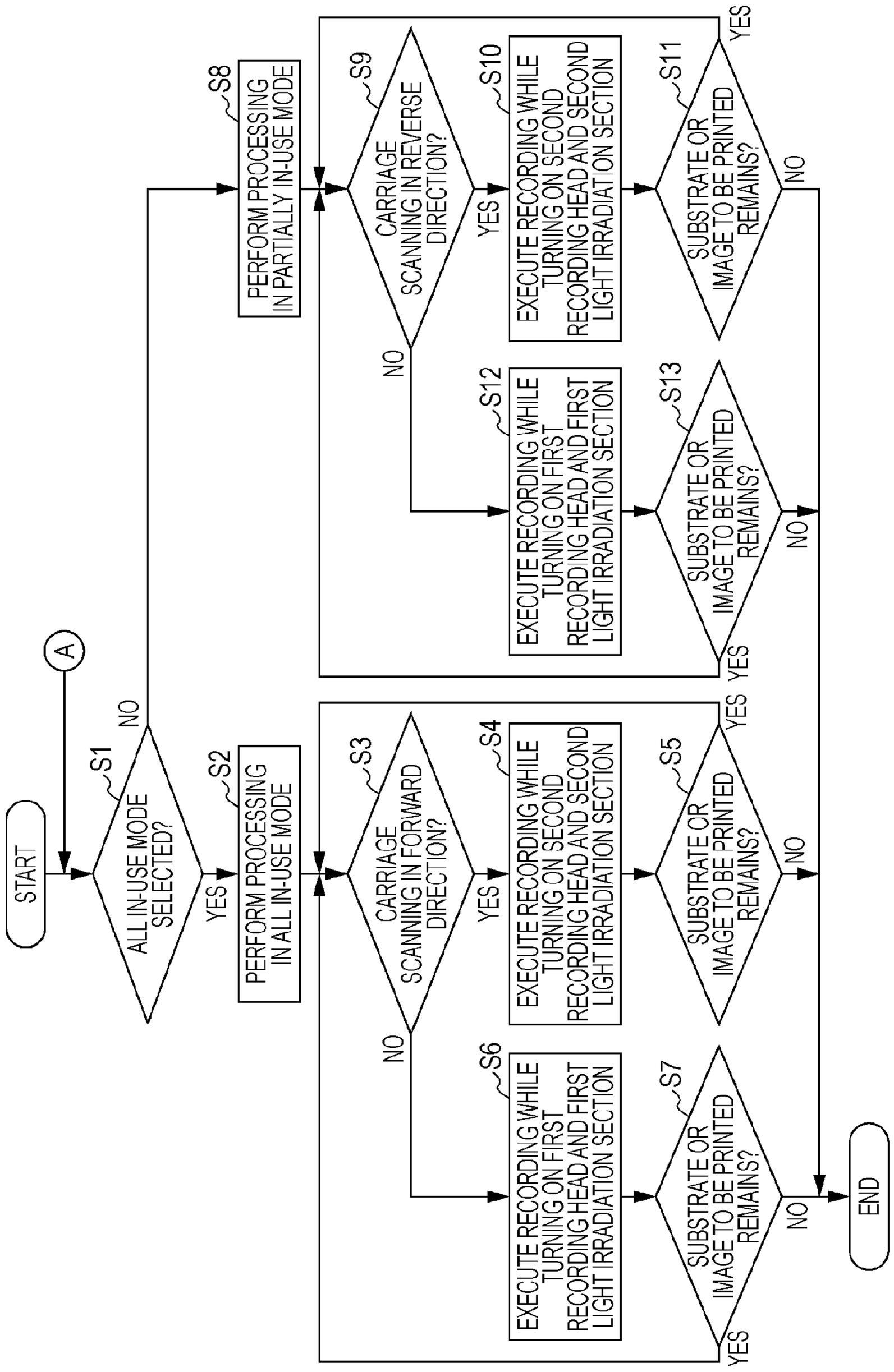
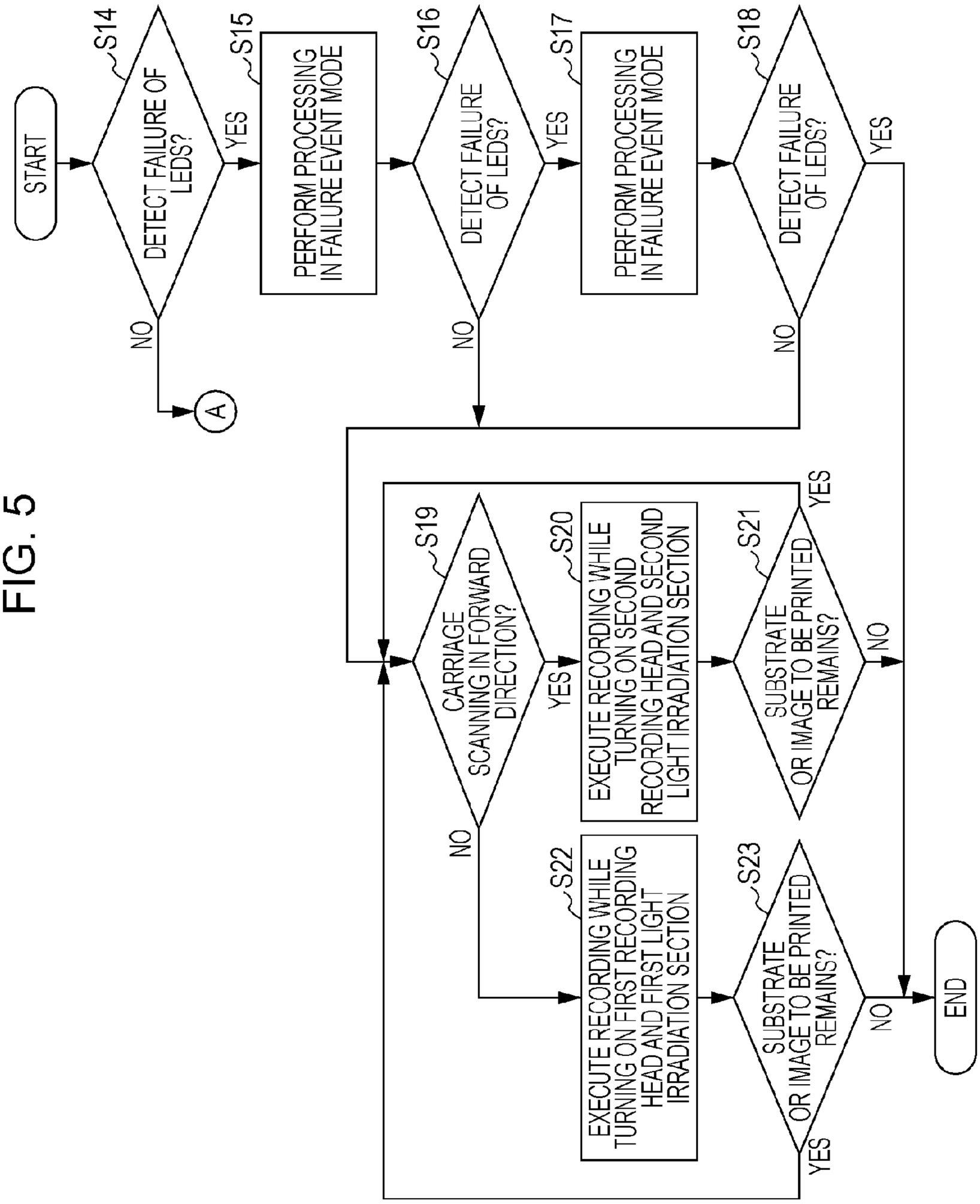

START
A
S1
ALL IN-USE MODE SELECTED?
NO
YES
S2
PERFORM PROCESSING IN ALL IN-USE MODE
S3
CARRIAGE SCANNING IN FORWARD DIRECTION?
NO
YES
S4
EXECUTE RECORDING WHILE TURNING ON SECOND RECORDING HEAD AND SECOND LIGHT IRRADIATION SECTION
S5
SUBSTRATE OR IMAGE TO BE PRINTED REMAINS?
YES
NO
S6
EXECUTE RECORDING WHILE TURNING ON FIRST RECORDING HEAD AND FIRST LIGHT IRRADIATION SECTION
S7
SUBSTRATE OR IMAGE TO BE PRINTED REMAINS?
YES
NO
END
S8
PERFORM PROCESSING IN PARTIALLY IN-USE MODE
S9
CARRIAGE SCANNING IN REVERSE DIRECTION?
NO
YES
S10
EXECUTE RECORDING WHILE TURNING ON SECOND RECORDING HEAD AND SECOND LIGHT IRRADIATION SECTION
S11
SUBSTRATE OR IMAGE TO BE PRINTED REMAINS?
YES
NO
S12
EXECUTE RECORDING WHILE TURNING ON FIRST RECORDING HEAD AND FIRST LIGHT IRRADIATION SECTION
S13
SUBSTRATE OR IMAGE TO BE PRINTED REMAINS?
YES
NO

FIG. 5


START
S14
DETECT FAILURE OF LEDS?
YES
NO
A
S15
PERFORM PROCESSING IN FAILURE EVENT MODE
S16
DETECT FAILURE OF LEDS?
YES
NO
S17
PERFORM PROCESSING IN FAILURE EVENT MODE
S18
DETECT FAILURE OF LEDS?
YES
NO
S19
CARRIAGE SCANNING IN FORWARD DIRECTION?
YES
NO
S20
EXECUTE RECORDING WHILE TURNING ON SECOND RECORDING HEAD AND SECOND LIGHT IRRADIATION SECTION
S21
SUBSTRATE OR IMAGE TO BE PRINTED REMAINS?
YES
NO
S22
EXECUTE RECORDING WHILE TURNING ON FIRST RECORDING HEAD AND FIRST LIGHT IRRADIATION SECTION
S23
SUBSTRATE OR IMAGE TO BE PRINTED REMAINS?
YES
NO
END

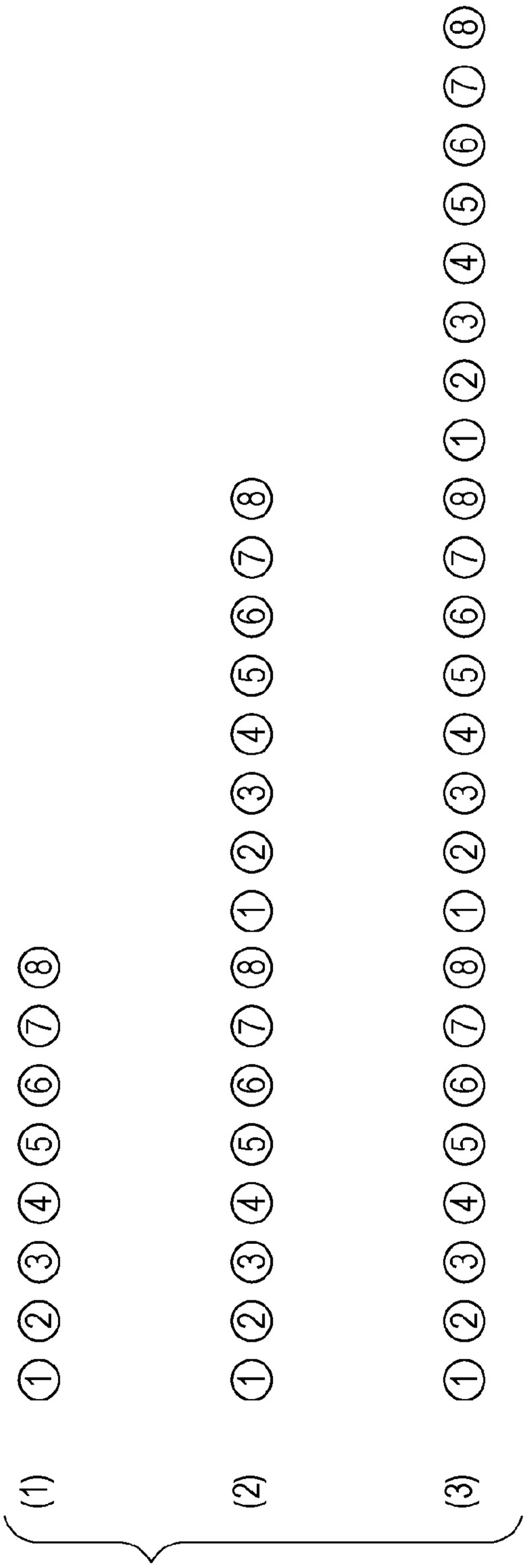


FIG. 6

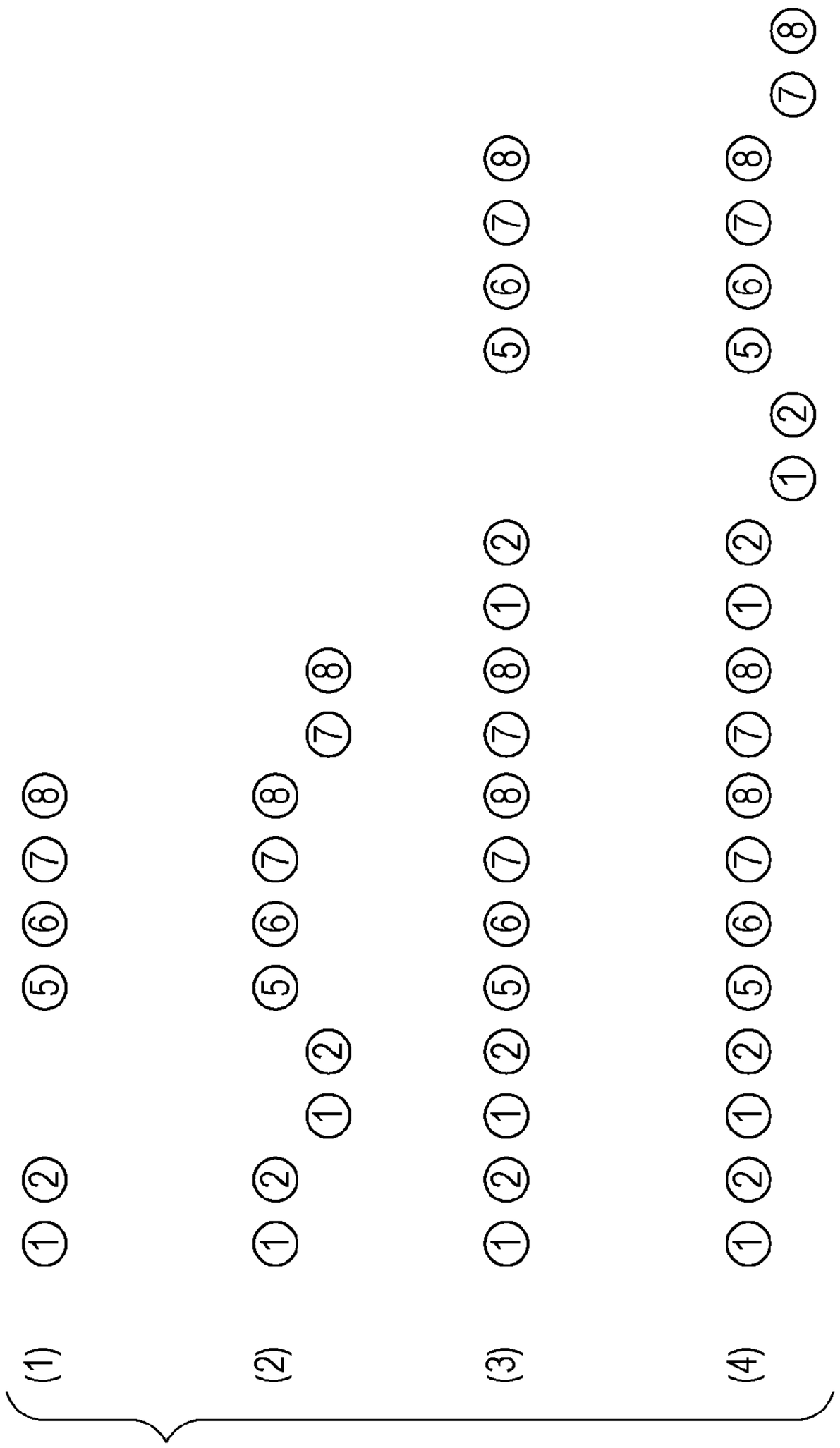


FIG. 7

RECORDING APPARATUS

BACKGROUND

1. Technical Field

The present invention relates to a recording apparatus that includes a transportation mechanism that transports a recording material, a recording head that reciprocates in a direction intersecting the transporting direction of the recording material, and a light irradiation section. The recording head has a nozzle row that discharges photoactive liquids onto the recording material being transported. The light irradiation section has a light emitting device row that irradiates the discharged photoactive liquids with light in order to chemically change the liquids. The light emitting device row and the nozzle row extend in the same direction.

2. Related Art

To date, recording apparatuses that include a recording head and a light irradiation section have been developed, as disclosed in JP-A-2005-104108 and JP-A-2004-314304. In such a recording apparatus, the recording head has a nozzle row where many nozzle openings are arranged that discharging light-curable inks (for example, ultraviolet (UV) curable inks) onto the recording surface of a recording material (hereinafter, also referred to as "paper"). In addition, the light irradiation section has a light emitting device row where multiple light emitting devices (for example, light emitting diodes (LEDs)) are arranged that irradiates the discharged light-curable inks with light in order to cure the inks.

In a recording apparatus having a carriage to which a recording head is attached and which reciprocates in a direction intersecting a transporting direction of paper, two light emitting device rows are arranged on respective sides of nozzle rows having various color inks, in order to irradiate light-curable inks with light upon both the forward and backward movements of the recording head, as described in the above-mentioned patent documents.

In the above recording apparatus, if one of the light emitting devices, such as LEDs, constituting the light emitting device row fails during a recording process, light-curable inks discharged from several tens of nozzle openings that correspond to the failed light emitting device are left uncured. In this case, a useless printed material having no commercial value may be produced.

Neither of the above-mentioned documents describes any measures against the failure of a light emitting device as described above. In consideration of a current market for available materials printed with light-curable inks, taking measures against the failure of a light emitting device has become an important issue.

Accordingly, it is desirable to be able to continue recording without leaving light-curable inks uncured, even if some light emitting devices fail.

SUMMARY

An advantage of some aspects of the invention is to provide a recording apparatus that is capable of continuing recording, even if some light emitting devices constituting a light irradiation section fail.

According to an aspect of the invention, a recording apparatus includes: a transportation mechanism that transports a recording material; a recording head that reciprocates in a direction intersecting a transporting direction of the recording material and that has a nozzle row discharging photoactive liquids onto the recording material being transported; a light irradiation section that has a light emitting device row where

a plurality of light emitting devices are arranged in an extending direction of the nozzle row, wherein the light emitting devices chemically change the photoactive liquids by irradiating the discharged photoactive liquids with light; a failure detection section that detects failure of the light emitting devices constituting the light emitting device row; and a control section that controls respective operations of the transportation mechanism, the recording head, and the light irradiation section. Furthermore, the control section has a failure event mode into which the control section goes when the failure detection section detects failure of at least one of the light emitting devices, and the failure event mode is configured to execute recording by masking at least one of nozzle openings constituting the nozzle row which corresponds to the failed light emitting device.

The term "light" used herein may refer to visible light that typically has a wavelength of 360 nm or 400 nm to 760 nm or 830 nm, ultraviolet light that has a wavelength shorter than the visible light, namely, a wavelength of approximately 1 nm to 380 nm, or infrared light that has a wavelength longer than the visible light, namely, a wavelength of approximately 780 nm to 1 mm. Furthermore, the above light may be an electromagnetic wave that has a wavelength shorter than the ultraviolet light or longer than the infrared light. Therefore, it is preferable that the term "light" be broadly interpreted, for the purpose of simplifying the following explanation.

Likewise, the term "photoactive liquid" used herein refers to various liquids that are chemically changed by reacting with typical light including visible light, ultraviolet light, and infrared light. In addition, the above light may be an electromagnetic wave that has a wavelength shorter or longer than the typical light, for the purpose of simplifying the following explanation.

In the recording apparatus according to this aspect, the failure event mode, into which the control section goes when the failure detection section detects failure of at least one of the light emitting devices, is configured to execute the recording by masking at least one of the nozzle openings constituting the nozzle row in the recording head which corresponds to the failed light emitting device. Accordingly, the nozzle opening that is responsible for the failed light emitting device does not discharge a photoactive liquid. Consequently, even if continuing recording upon failure of any of the light emitting devices, the light emitting device can execute the recording without leaving a photoactive liquid uncured.

In the recording apparatus according to this aspect, it is preferable that the control section change an amount by which the transportation mechanism feeds the transportation material during a subsequent recording operation, at a location where a photoactive liquid should be discharged from the masked nozzle opening. In addition, it is preferable that the recording be executed while the unmasked nozzle openings and this location are aligned.

The above recording apparatus executes the recording while masking the nozzle opening corresponding to the failed light emitting device. Accordingly, due to this masking, there is a location at which a photoactive liquid is not discharged. However, the control section changes an amount by which the transportation mechanism feeds the recording material during a subsequent recording operation and, then executes the recording while the unmasked nozzle openings and the above location are aligned. This enables the recording to be executed without causing the deficiency of discharged photoactive liquids.

In this case, since the light emitting devices that are responsible for the unmasked nozzle openings are not defective, the

photoactive liquids discharged from the unmasked nozzle openings are irradiated with the light, and then, are cured.

It is preferable that the recording apparatus according to this aspect be configured to execute the recording by means of a recording method employing at least one of band feeding recording and high resolution recording. In addition, it is preferable that the control section have an alternate recording mode in advance, in which the recording method that has been used prior to an occurrence of the failure is continued to be used by using all or some of the unmasked nozzle openings while the nozzle opening that corresponds to the failed light emitting device is masked.

The above recording apparatus has the alternate recording mode, in order to deal with possible failure of the light emitting devices. This alternate recording mode makes it possible to continue to use the recording method that has been performed prior to an occurrence of the failure, by using all or some of the unmasked nozzle openings. Consequently, it is possible for the control section to go into the failure event mode, immediately after one or more of the light emitting devices fail, and to continue the recording.

In the recording apparatus according to this aspect, it is preferable that the light emitting device row in the light irradiation section include a plurality of light emitting device rows.

As described above, the light emitting device row in the light irradiation section includes the multiple light emitting device rows.

When the light emitting devices in all the light emitting device rows are turned on and are used, the total irradiation intensity of the light emitted from all the light emitting devices may simply be high enough to chemically change the photoactive liquids. Accordingly, the light irradiation intensity of each light emitting device in one of the light emitting device rows may be set to be lower than that of a typical recording apparatus provided with a single light emitting device row. This enables the load of the light emitting devices upon emitting to be lightened, so that the risk of the failure of the light emitting devices is decreased.

Moreover, the light emitting devices in all the light emitting device rows may not be turned on. Instead, the light emitting devices in one or some of the light emitting device rows may be turned on.

In this case, the light irradiation intensity of one of the light emitting devices is higher than that when all the light emitting device rows are used, but still may be set to be lower than that of a typical recording apparatus provided with a single light emitting device row. In addition, the selected light emitting device row or rows to be turned on may be exchanged, for each irradiation or every regular period. This decreases the frequency of using or lighting of the light emitting devices, thereby lightening the load of the light emitting devices upon emitting, as well as decreasing the risk of the failure thereof.

In the above aspect, an example of the photoactive liquid is an ultraviolet (UV) curable ink, and an example of light emitting device is a light emitting diode (LED) for emitting an ultraviolet (UV) ray.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

FIG. **1** is a front view schematically depicting a main part of an internal structure of a recording apparatus according to an embodiment of the invention.

FIG. **2** is a plan view depicting the main part of the schematic internal structure of the recording apparatus according to the embodiment of the invention.

FIG. **3** is a schematically enlarged view depicting light emitting device rows in the recording apparatus according to the embodiment of the invention.

FIG. **4** is a flowchart depicting an operation in a normal mode of the recording apparatus according to the embodiment of the invention.

FIG. **5** is a flowchart depicting an operation in a failure event mode of the recording apparatus according to the embodiment of the invention.

FIG. **6** is a view for explaining a function and effect of the recording apparatus according to the embodiment of the invention, when the recording apparatus operates in the normal mode.

FIG. **7** is a view for explaining a function and effect of the recording apparatus according to the embodiment of the invention, when the recording apparatus operates in the failure event mode.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

A specific description will be given below of a structure and function of a recording apparatus **1** according to embodiments of the invention, with reference to FIGS. **1** to **7**.

Thereinafter, first, a basic structure of a recording apparatus **1** according to embodiments of the invention will be described on the basis of FIGS. **1** and **2**. Then, a characteristic structure thereof will be described on the basis of the embodiments of the invention.

Embodiment (Refer to FIGS. **1** to **7**)

A recording apparatus **1** shown in FIG. **1** is an ink jet printer **1** that enables band feeding recording. Note that the reference numeral of the recording apparatus is also given to the ink jet printer, and band feeding recording is also referred to as "band feeding printing". This ink jet printer **1** includes a transportation mechanism **3**, a recording head unit **15**, light irradiation sections **19**A and **19**B, failure detection sections **20** and **20**, and a control section **21**. Specifically, the transportation mechanism **3** transports a recording material P in a transporting direction A. The recording head unit **15** has nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K that discharge photoactive liquids C**1** and C**2** onto the recording material P being transported, and reciprocates in a direction B intersecting the transporting direction A. Each of the light irradiation sections **19**A and **19**B has light emitting device rows **39**A, **39**B and **39**C, and each light emitting device row has light emitting devices **41** aligned in an extending direction of the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K. The light emitting devices **41** irradiate the discharged photoactive liquids C**1** and C**2** with light E, in order to chemically change the liquids C**1** and C**2**. The failure detection section **20** detects failure of the light emitting devices **41** constituting the light emitting device rows **39**A, **39**B and **39**C. The control section **21** controls the respective operations of the transportation mechanism **3**, the recording head unit **15**, and the light irradiation sections **19**A and **19**B.

Furthermore, the control section **21** has a failure event mode **45** into which the control section **21** goes when the failure detection section **20** detects failure of at least one of the light emitting devices **41**. This failure event mode **45** is configured to enable recording by masking some of the nozzle openings **7** constituting the nozzle rows **5**W, **5**C, **5**M,

5Y and 5K which correspond to the failed light emitting device **41**, when one of the light emitting devices **41** fails. In this embodiment, the light emitting device rows **39**A, **39**B and **39**C are arranged in each of the light irradiation sections **19**A and **19**B.

In more detail, the ink jet printer **1** includes the transportation mechanism **3** that can transport the paper P intermittently in the transporting direction A by a predetermined band feeding amount D, and the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K, each of which has the nozzle openings **7** aligned in the transporting direction A. These nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K are arranged in the direction B intersecting the transporting direction A. Furthermore, the ink jet printer **1** includes the recording head unit **15** which forms desired substrates **11** and images **13** on a recording surface **9** of the paper P with ultraviolet (UV) curable inks C**1** and C**2**, which are an example of photoactive liquids, discharged from the nozzle openings **7** constituting the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K.

Herein, the term "band" refers to a recording execution region having a length in the transporting direction A, which corresponds to a whole length of the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K in the transporting direction A of the recording material P, or a product having the above recording execution region.

In addition, the term "band feeding amount" refers to a feeding amount by which the recording material P is actually transported whenever recording is executed for each band.

Moreover, the ink jet printer **1** includes a carriage **17** and the light irradiation sections **19**A and **19**B. The carriage **17** is provided with the recording head unit **15**, and reciprocates in the intersecting direction B. The light irradiation sections **19**A and **19**B are attached to the carriage **17**, so as to be arranged on the respective sides of the recording head unit **15** in the intersecting direction B. Each of the light irradiation sections **19**A and **19**B includes the light emitting device rows **39**A, **39**B and **39**C. Each of the light emitting device rows **39**A, **39**B and **39**C is formed of multiple light emitting diodes **41** (also referred to as "LEDs"), which are an example of the light emitting devices, and the LEDs **41** irradiate the ultraviolet (UV) curable inks C**1** and C**2** discharged from the nozzle openings **7** with ultraviolet rays (UV light) E, which is an example of the light E for chemically changing (for example, curing) the inks C**1** and C**2**.

The light emitting device rows **39**A, **39**B and **39**C are arranged in the direction B intersecting the transporting direction A of the paper P. Details of this will be described later.

In addition, an ultraviolet ray (UV light) emitted from one of the LEDs **41** constituting the light emitting device rows **39**A, **39**B and **39**C are used to cure multiple ultraviolet (UV) curable inks discharged individually from some of the nozzle openings **7** constituting the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K.

In this embodiment, an ultraviolet ray (UV light) E emitted from a single LED **41** cures ultraviolet (UV) curable inks discharged from approximately thirty six nozzle openings **7** at the same time.

As shown in FIGS. **1** and **2**, the transportation mechanism **3** includes, for example, a transporting roller unit **25** composed of a pair of nip rollers disposed upstream of the recording execution region **23**, and an ejection roller unit **27** composed of a pair of nip rollers disposed downstream of the recording execution region **23**.

Both the transporting roller unit **25** and the ejection roller unit **27** are driven by a motor **29**. This motor **29** feeds the paper P intermittently by the band feeding amount D, in response to a signal **31** for instructing the transportation of the paper P by the band feeding amount D which is transmitted from the control section **21** (described later).

In this embodiment, the recording head unit **15** includes two types of heads, namely, a first recording head **15**A that discharges the inks C**1** for substrates, and a second recording head **15**B that discharges the inks C**2** for forming images. For example, the first recording head **15**A is disposed on the left side in FIG. **1** or **2**, whereas the second recording head **15**B is disposed on the right side in FIG. **1** or **2**.

The first recording head **15**A is provided with the nozzle row **5**W that discharges the inks C**1** of, for example, white (W), gold (G), silver (S), etc., for substrates. Meanwhile, the second recording head **15**B is provided with the nozzle rows **5**C, **5**M, **5**Y and **5**K that discharge the inks C**2** of, for example, cyan (C), magenta (M), yellow (Y), and black (B), for forming images. In addition, the nozzle rows **5**C, **5**M, **5**Y and **5**K are arranged at predetermined intervals in the intersecting direction B.

The control section **21** (described later) transmits, to the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K, signals **32** for instructing a discharging amount of an ink which corresponds to a location of each of the nozzle openings **7**. With these signals, the discharging amounts of the inks are adjusted.

Note that the inks C**1** and C**2** discharged from the nozzle openings **7** of the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K in the ink jet printer **1** are ultraviolet (UV) curable inks, which are to be cured by being exposed to the irradiation of the ultraviolet rays (UV light) E, as described above.

The term "UV ink" refers to an ink that is to be cured and fixed excellently rapidly by being exposed to the irradiation of the UV light (ultraviolet rays) E, and a volume shrinkage ratio upon curing of this ink is much lower than that of known inks that are to be cured and fixed by a heater evaporating a solvent.

Moreover, since they do not contain any solvent components, UV inks are safe for the environment. In addition, UV inks are cured rapidly by being exposed to the irradiation of the UV light (ultraviolet ray) E. Therefore, UV inks are suitable for a film-based material having a low ink absorption ability, such as the recording material P.

The carriage **17** is a reciprocating transportation mechanism that reciprocates the recording head unit **15** along a carriage guide axis **37** extending in the intersecting direction B.

This carriage **17** is supplied with power for reciprocating the carriage **17** from a motor (not shown). This motor can rotate in the forward or reverse direction and control the feeding of the carriage **17** precisely in multiple steps. Specifically, the rotation power of this motor is transmitted to the carriage **17** through a toothed belt.

The first light irradiation section **19**A that cures the inks C**1** for substrates is disposed, for example, on the left side in FIG. **1** or **2**, whereas the second light irradiation section **19**B that cures the inks C**2** for forming images is disposed, for example, on the right side in FIG. **1** or **2**.

In the ink jet printer **1** shown in FIGS. **1** and **2**, the light irradiation sections **19**A and **19**B irradiate the ultraviolet (UV) curable inks C**1** and C**2**, which have been discharged onto the recording surface **9** of the paper P, with the ultraviolet rays (UV light) E having a predetermined intensity, thereby curing and fixing the ultraviolet (UV) curable inks C**1** and C**2**.

In this embodiment, each of the light irradiation sections **19**A and **19**B includes the light emitting device rows **39**A, **39**B and **39**C. Each of the light emitting device rows **39**A, **39**B and **39**C is provided with the LEDs **41**, which are arranged corresponding to the arrangement of the nozzle

openings **7** in the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K of the recording heads **15**A and **15**B.

The control section **21** (described later) transmits, to the LEDs **41**, signals **31** for instructing the executing or stopping of the irradiation of the ultraviolet ray (UV light) E and the irradiation intensity thereof corresponding to the location of each LED **41**. With these signals **31**, the irradiation of the ultraviolet rays (UV light) E is executed or stopped, and the irradiation intensity thereof is adjusted.

The above-described ink jet printer **1** of the embodiment includes the failure detection sections **20** and **20**, and the control section **21**, in addition to the above-described components. The failure detection sections **20** and **20** detect the failure of the LEDs **41** constituting the light emitting device rows **39**A, **39**B and **39**C. The control section **21** switches between a normal mode **43** and the failure event mode **45** in which the recording heads **15**A and **15**B and the light irradiation sections **19**A and **19**B are to operate, on the basis of failure detection information **33** from the failure detection sections **20** and **20** and preset setting information **35**. Then, the control section **21** causes the recording heads **15**A and **15**B and the light irradiation sections **19**A and **19**B to operate in the switched mode.

The failure detection section **20** may employ, for example, a mechanism that senses the operating temperature of each LED **41** or a variation in a voltage of a circuit in order to check each LED **41**, and discriminates between the normal and abnormal (or defective) operations of each LED **41**, on the basis of the sensed result.

The control section **21** switches between the operations of the recording heads **15**A and **15**B and between the light irradiation sections **19**A and **19**B as appropriate, depending on a moving direction of the carriage **17**. In addition, the control section **21** causes the selected recording head and light irradiation section to selectively operate in one of the normal mode **43** and the failure event mode **45**.

The normal mode **43** can be used by switching between an all in-use mode **49** and a partially in-use mode **51**, in accordance with a user's selection. In the all in-use mode **49**, all the light emitting device rows **39**A, **39**B and **39**C are used, whereas in the partially in-use mode **51**, one or two of the light emitting device rows **39**A, **39**B and **39**C are used.

In the all in-use mode **49**, the light irradiation sections **19**A and **19**B are switched, depending on whether the carriage **17** scans in the forward or reverse direction. Furthermore, in the all in-use mode **49**, all the LEDs **41** constituting the light emitting device rows **39**A, **39**B, **39**C in one of the light irradiation sections **19**A and **19**B in use turn on, and perform the irradiation of the ultraviolet rays (UV light) E.

Meanwhile, in the partially in-use mode **51**, the light irradiation sections **19**A and **19**B are switched, depending on a scanning direction of the carriage **17**. Furthermore, one or two light emitting devices are selected among the light emitting device rows **39**A, **39**B and **39**C in one of the light irradiation sections **19**A and **19**B in use. Following this, the selected rows are exchanged for each irradiation or every regular period. Finally, LEDs **41** on the selected light emitting device row or rows turn on, whereas the LEDs **41** in the other light emitting device rows or row turn off, and then, the active LEDs **41** performs the irradiation of the ultraviolet rays (UV light) E.

The selection of one or two light emitting device rows among the light emitting device rows **39**A, **39**B and **39**C may be made regularly, on the basis of the total numbers of lightings of the light emitting device rows **39**A, **39**B and **39**C or the total lighting periods thereof, or may be made randomly.

As described above, the failure event mode **45** makes it possible to execute recording while masking some of the nozzle openings **7** constituting the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K which correspond to a failed light emitting device **41**. Moreover, in this embodiment, if an auxiliary light emitting device row is available, when the failure of one of the LEDs **41** in the light emitting device rows **39**A, **39**B and **39**C is detected, the failure event mode **45** may stop using the light emitting device row having the failed LED **41**, and may use a light emitting device row having no defective LEDs **41**, instead of the light emitting device row having the failed LED **42**.

Furthermore, in this embodiment, as shown in FIG. **3**, the LEDs **41** of each of the light emitting device rows **39**A, **39**B and **39**C are placed at regular intervals S in the transporting direction A of the paper P. In addition, the respective, corresponding LEDs **41** of the light emitting device rows **39**A, **39**B and **39**C are placed at the same position in the transporting direction A.

Accordingly, when an LED **41** in one of the light emitting device rows **39**A, **39**B and **39**C fails, an LED **41** in another one of the light emitting device rows **39**A, **39**B and **39**C, which is located at the same position as the failed LED **41** in the transporting direction A, operates to make up for the shortage of the light irradiation intensity due to the failed LED **41**.

Therefore, even if an LED **41** in one of the light emitting device rows **39**A, **39**B and **39**C fails, one or more LEDs **41** of another row or the other rows, which are located at the same position as the failed LED **41** in the transporting direction A, make up for the shortage of the light irradiation intensity due to the failed LED **41**. This enables the desired ultraviolet (UV) curable inks C**1** and C**2** to be cured by means of the irradiation of the ultraviolet rays (UV light) E having the compensated intensity.

Next, a specific description will be given of an operation flow of the ink jet printer **1** according to this embodiment, with reference to flowcharts shown in FIGS. **4** and **5**. Note that the following description is given by breaking down an operation of the ink jet printer **1** into those in the normal and failure event modes.

Operation in Normal Mode (Refer to FIG. **4**)

In this embodiment, when none of the LEDs **41** fails, the control section **21** selects the normal mode **43** shown in FIG. **4**. At a step S**1**, first, the control section **21** determines which of the all in-use mode **49** and the partially in-use mode **51** has been selected. If it is determined that the all in-use mode **49** has been selected, the processing proceeds to a step S**2**, and recording is to be executed in the all in-use mode **49**.

Upon operation in the all in-use mode **49**, the total irradiation intensity of the light E that is emitted from all the LEDs **41** in the light emitting device rows **39**A, **39**B and **39**C may simply be high enough to chemically change the photoactive liquids. Accordingly, the light irradiation intensity of each LED **41** in one of the light emitting device rows **39**A, **39**B and **39**C may be set to be lower than that of a typical recording apparatus provided with a single light emitting device row. This enables the load of the LEDs **41** upon emitting to be lightened, so that the risk of the failure of the LEDs **41** is decreased.

Next, the processing proceeds to a step S**3**, and the control section **21** determines whether the moving (or scanning) direction of the carriage **17** is forward or reverse. If it is determined that the moving direction of the carriage **17** is forward, the processing proceeds to a step S**4**. Then, the

control section **21** executes recording while turning on the second recording head **15**B and the second light irradiation section **19**B and turning off the first recording head **15**A and the first light irradiation section **19**A.

Next, the recording processing proceeds to a step S**5**, and the control section **21** determines whether or not any substrate **11** or image **13** to be printed remains. If it is determined that no substrate **11** or image **13** to be printed remains, the control section **21** terminates the processing.

Meanwhile, if it is determined that any substrate **11** or image **13** to be printed remains at the step S**5**, the processing returns to the step S**3**. Then, the control section **21** repeats the determinations and operation of the steps S**3** to S**5**.

On the other hand, if it is determined that the moving direction of the carriage **17** is reverse at the step S**3**, the recording processing proceeds to a step S**6**. Then, the control section **21** executes recording while turning on the first recording head **15**A and the first light irradiation section **19**A and turning off the second recording head **15**B and the second light irradiation section **19**B.

Then, the recording processing proceeds to a step S**7**, and the control section **21** determines whether or not any substrate **11** or image **13** to be printed remains. If it is determined that no substrate **11** or image **13** to be printed remains, the control section **21** terminates the processing.

Meanwhile, if any substrate **11** or image **13** to be printed is determined to remain at the step S**7**, the processing returns to the step S**3**. Then, the control section **21** repeats the determinations and operations of the steps S**3**, S**6** and S**7** or the determinations and operations of the steps S**3** to S**5**.

On the other hand, it is determined that the partially in-use mode **51** is selected at the step S**1**, the processing proceeds to a step S**8**. Then, the control section **21** executes processing while switching between the light emitting device rows **39**A, **39**B and **39**C to be used, as appropriate, in accordance with the preset setting information **35**.

In this case, the light irradiation intensity of one LED **41** is higher than that when all the light emitting device rows **39**A, **39**B and **39**C are used, but still may be set to be lower than that of a typical recording apparatus provided with a single light emitting device row. In addition, the selected light emitting device rows for emitting the light E are exchanged for each irradiation. This decreases the frequency of using or lighting of the LEDs **41**, thereby lightening the load of the LEDs **41** upon emitting, as well as decreasing the risk of the failure of the LEDs **41**.

In this embodiment, the respective, corresponding LEDs **41** in the light emitting device rows **39**A, **39**B and **39**C are placed at the same position in the extending direction of the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K. Accordingly, even if the selected light emitting device rows for emitting the light E are exchanged for each irradiation, the total light irradiation intensity of the light E applied to the photoactive liquids is not changed. This prevents the variation in the recording quality.

Thereafter, the control section **21** performs determinations and operations of steps S**9** to S**13** which are the same as those in the steps S**3** to S**7**, respectively. Then, if it is determined that no substrate **11** or image **13** to be printed remains at the step S**11** or S**13**, the control section **21** terminates the processing.

Operation in Failure Event Mode (Refer to FIG. **5**)

At a step S**14**, first, the control section **21** makes a determination whether to have received failure detection information **33** from the failure detection section **20**. If it is determined that the failure detection section **20** has detected the failure of any of the LEDs **41**, the processing proceeds to an operation in the failure event mode at a step S**15**. In this failure event mode, if an auxiliary light emitting device row is available, the control section **21** executes recording while replacing the light emitting device row having the failed LED **41** with another one. Note that a description will be given later of an operation when no auxiliary light emitting device row is available.

Subsequently, the processing proceeds to a step S**16**, and the control section **21** makes a second determination whether to have received failure detection information **33** from the failure detection section **20**.

If it is determined that the failure detection section **20** has detected the failure of any of the LEDs **41**, the recording processing proceeds to a step S**17**. Then, the control section **21** executes recording while replacing the light emitting device row having the failed LED **41** with the remaining one.

Next, the processing proceeds to a step S**18**, the control section **21** makes a third determination whether to have received failure detection information **33** from the failure detection section **20**. If it is determined that the failure detection section **20** has detected the failure of any of the LEDs **41**, the control section **21** terminates the processing, because if this processing were continued, a defective printed material would be produced.

Meanwhile, if the failure of the LEDs **41** is not detected at the step S**16** or S**18**, the processing proceeds to a step S**19**. Then, the control section **21** performs determinations and operations at steps S**19** to S**23** that are the same as those in the steps S**3** to S**7** shown in FIG. **4**. If it is determined that no substrate **11** or image **13** to be printed remains at the step S**21** or S**23**, the control section **21** terminates the recording.

On the other hand, if the failure of the LEDs **41** is not detected at the step S**14**, the processing proceeds to the step S**1** shown in FIG. **4**, and the control section **21** performs the operation in the normal mode.

The ink jet printer **1** of the embodiment that has the above-configured structure prevents the occurrence of situations where useless printed materials having no commercial value are produced as a result from the failure of the LEDs **41**, and the ultraviolet (UV) curable inks are wasted. This effect is significant, especially when the ink jet printer **1** operates automatically.

In addition, the recording apparatus **1** prevents the occurrence of a trouble in which uncured ultraviolet (UV) curable inks that stay in the interior and are adhered to any members or the like deteriorate the performance.

Detailed Operation in Failure Event Mode (Refer to FIGS. **6**A to **6**C and FIGS. **7**A to **7**D)

FIGS. **6**A to **6**C depict an example of the band feeding recording, and schematically illustrate the recorded state generated by an operation in the normal mode, which is performed when none of the LEDs **41** fails. In this example, band feedings for one to three passes are illustrated for the purpose of clarifying a relationship between the respective band feedings and eight nozzle openings **7**.

When the recording head executes recording for the first pass, all the nozzle openings (or first to eighth nozzle openings) **7** discharge photoactive liquids (refer to FIG. **6**A). Subsequently, the transportation mechanism **3** carries out band feeding by a band feeding amount D, and then, the recording head executes recording for the second pass (refer to FIG. **6**B). Finally, the transportation mechanism **3** carries out band

feeding by the band feeding amount D, and then, the recording head executes recording for the third pass (refer to FIG. **6**C).

FIGS. **7**A to **7**D depict another example of band feeding recording, and schematically illustrate the recording state generated by an operation in the failure event mode that is performed when at least one of the LEDs **41** fails. In this example, band feedings for one to four passes are illustrated for the purpose of clarifying a relationship between the respective band feedings and eight nozzle openings **7**. In addition, in the example, the nozzles **7** of Nos. 3 and 4 are masked as a result from the failure of one or more of the LEDs **41**.

Upon the recording operation for the first pass, photoactive liquids are not discharged onto positions that correspond to the masked nozzle openings **7** (of Nos. 3 and 4) (refer to FIG. **7**A). Then, the transportation mechanism **3** does not carry out band feeding by the band feeding amount D. Instead, the transportation mechanism **3** carries out band feeding by an amount necessary for the nozzle openings **7** of Nos. 1 and 2 to be disposed at the respective positions where photoactive liquids are not discharged. Subsequently, the recording head executes recording for the second pass (refer to FIGS. **7**B). This recording for the second pass is executed while the nozzle openings **7** of Nos. 3 to 6 are masked. This prevents the deficiency of the discharged photoactive liquids, as shown in FIG. **7**B. Note that in FIG. **7**B, the photoactive liquids discharged upon recording for the first and second passes are slightly shifted from one another, for the purpose of easily discriminating between respective liquids discharged for the first and second passes. This is also applied to FIG. **7**D described later.

Then, the transportation mechanism **3** carries out band feeding by the band feeding amount D, and the recording heads executes recording for the third pass (refer to FIG. **7**C). Similar to the printed state shown in FIG. **7**A, photoactive liquids are not discharged onto positions that correspond to the masked nozzle openings **7** (of Nos. 3 and 4) (refer to FIG. **7**C). Finally, the transportation mechanism **3** carries out band feeding and the recording head executes recording in the same way as that shown in FIG. **7**B, thereby also preventing the deficiency of the discharged photoactive liquids (refer to FIG. **7**D).

Thereafter, the same processing is repeated, so that recording is executed without causing the deficiency of photoactive liquids.

The above description has been given, in the case where the nozzle openings **7** of Nos. 3 and 4 are masked as a result from the failure of the LEDs **41**. However, this description can also be applied to a case where nozzle openings of other numbers are masked.

Moreover, in the example shown in FIG. **7**A to **7**D, only the nozzle openings of Nos. 5 to 8, namely, only ones at the ends of the nozzle rows **5**W, **5**C, **5**M, **5**Y and **5**K are used to perform the recording operation, for the purpose of simplifying the band feeding.

FIGS. **6**A to **6**C and FIGS. **7**A to **7**D show the examples in which the recording apparatus **1** according to the embodiment of the present invention is applied to a recording apparatus for the band feeding recording. However, the recording apparatus **1** may also be applied to a recording apparatus for high resolution recording. The term "high resolution recording" refers to a method of recording images or the like in a resolution that is as fine as or finer than the interval of the nozzle openings **7**. Examples of this method include known microwave recording, and normal high resolution recording that repeats small amount feeding and large amount feeding.

Another Embodiment

The recording apparatus **1** according to the embodiment of the invention basically has the above-described structure. However, it is obvious that various partial modifications to the structure or omissions thereof be possible without departing from the spirit of the invention of this application.

For example, the control section **21** may include an alternate recording mode in advance, in which the recording method that has been used prior to the occurrence of the failure can be continued to be used by using all or some of the unmasked nozzle openings **7**, when at least one of the light emitting device **41** fails and some of the nozzle openings **7** that correspond to the failed light emitting device **41** are masked. Consequently, the recording operation can go into the failure event mode immediately after any of the light emitting devices **41** fails, and then, continue the recording operation.

Although each of the light irradiation sections **19**A and **19**B has the three light emitting device rows **39**A, **39**B and **39**C in this embodiment, the number of light emitting device rows is not limited to three. Alternatively, two or more than three light emitting device rows may be provided.

If the ink jet printer **1** is an exclusive printer for the images **13**, the ink jet printer **1** may be provided with only the second recording head **15**B for forming images, and a pair of irradiation sections **19**B may be provided close to and on the respective sides of the second recording head **15**B in the direction B.

In this case, the control section **21** does not need to turn on/off the second recording head **15**B and the second light irradiation sections **19**B, depending on whether the moving direction of the carriage **17** is forward or reverse. This makes it easy for the control section **21** to control the operation of the recording head and the light irradiation section.

The light irradiation intensity of the LEDs **41** may be adjusted individually, depending on whether the operation mode is the normal mode **43** or the failure event mode **45**. In addition, the light irradiation intensity of an LED **41** that makes up for a failed LED may be adjusted depending on the position of the failed LED. Furthermore, the light irradiation intensity of each LED **41** may be adjusted, depending on a distance between the recording head unit **15** and the light emitting device row where this LED **41** is disposed.

The photoactive liquids C**1** and C**2** discharged from the recording head unit **15** are not limited to ultraviolet (UV) curable inks. Alternatively, various photoactive liquids that are to be chemically changed by being exposed to the irradiation of a light ray of a certain wavelength other than ultraviolet ray (UV light) may be employed. In addition, the light emitting devices **41** may not be LEDs. Specifically, any photoactive liquid, the color of which is to be changed by being exposed to the irradiation of a light ray of a certain wavelength, may be applied to the ink jet printer **1** according to the embodiments of the invention which is configured to form the images **13** on the recording surface **9** of the recording material P.

The entire disclosure of Japanese Patent Application No. 2011-087542, filed on Apr. 11, 2011 is expressly incorporated by reference herein.

What is claimed is:

1. A recording apparatus comprising:

a transportation mechanism that transports a recording material;

a recording head that reciprocates in a direction intersecting a transporting direction of the recording material, the

recording head having a nozzle row discharging photoactive liquids onto the recording material being transported;

a light irradiation section that has a light emitting device row where a plurality of light emitting devices are arranged in an extending direction of the nozzle row, the light emitting devices chemically changing the photoactive liquids by irradiating the discharged photoactive liquids with light;

a failure detection section that detects failure of the light emitting devices constituting the light emitting device row; and

a control section that controls respective operations of the transportation mechanism, the recording head, and the light irradiation section,

wherein the control section has a failure event mode into which the control section goes when the failure detection section detects failure of at least one of the light emitting devices, and the failure event mode is configured to execute recording by masking at least one of nozzle openings constituting the nozzle row which corresponds to the failed light emitting device.

2. The recording apparatus according to claim **1**,

wherein the control section changes an amount by which the transportation mechanism feeds the transportation material during a subsequent recording operation, at a location where the photoactive liquids should be discharged from the masked nozzle openings, and the recording is executed while the unmasked nozzle openings and the location are aligned.

3. The recording apparatus according to claim **1**

wherein the recording apparatus is configured to execute the recording by means of a recording method employing at least one of band feeding recording and high resolution recording, and

wherein the control section is equipped with an alternate recording mode in advance, in which the recording method that has been used prior to an occurrence of the failure is continued to be used by using all or some of the unmasked nozzle openings, while the nozzle opening that corresponds to the failed light emitting device is masked.

4. The recording apparatus according to claim **1**,

wherein the light emitting device row in the light irradiation section includes a plurality of light emitting device rows.

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